Answers - Point Source Lab

Calculation 1. Boiler Emissions (CEM Data)

Calculating Hourly Emissions of SO_2

$$E_{SO2} = \frac{(C \times MW \times Q \times 60)}{(V \times 10^6)}$$

$$E_{SO2} = \frac{1{,}058.8 \times 64 \times 155{,}272 \times 60}{385.5 \times 10^6} = 1{,}637 \text{ lb/hr}$$

Calculation 1. Boiler Emissions (CEM Data)

Calculating Heat Input

$$H_{in} = \frac{(Q_f \text{ x HHV})}{(10^6)}$$

$$H_{in} = \frac{46{,}000 \text{ x } 18{,}000}{10^6} = 828 \text{ MMBtu/hr}$$

Calculation 1. Boiler Emissions (CEM Data)

Developing SO_2 Emission Factors

$$EF_{SO2} = \frac{E_{SO2}}{H_{in}} = \frac{1{,}637 \text{ lb/hr}}{828 \text{ MMBtu/hr}} = 1.98 \text{ lb/MMBtu}$$

Calculation 1. Boiler Emissions (CEM Data)

Calculating Annual SO2 Emissions

Annual SO_2 Emissions = Hourly SO_2 emissions x Op Hrs

$$= \frac{(1{,}637 \text{ lb/hr} \times 5{,}400 \text{ hrs})}{(2{,}000 \text{ lb/ton})} = 4{,}419 \text{ tons per year}$$

Calculation 2. Boiler Emissions (Source Testing)

P_b Emission Rate = P_b concentration
x stack gas flow rate

= 0.0005 lb/dscf x 51,700 dscf/min x 60 min/hr

= 1,551 lb/hr

Annual P_b Emissions = 1,551 lb/hr x 5,840 hr/yr
x 1 ton/2,000 lb = 4,528 tpy

Calculation 3. Copper Coil Manufacturing (Mass Balance)

Consumption = (mass of coil and oil to annealer - mass of coil processed) x 85 percent

= (5,075 kg - 5,000 kg) x 0.85

= 64 kg oil destroyed in the annealer

Calculation 3. Copper Coil Manufacturing (Mass Balance)

Estimate of Output (emissions)

Output = Input - Consumption - Accumulation

= 3,000 kg - 64 kg - 2,800 kg

= 136 kg

The VOC emissions associated with this process are thus 136 kg oil pr 5,000 kg of copper coil process, or 0.027 kg oil per kg of copper coil processed.

Calculation 4. Boiler Emissions (Fuel Analysis)

$E_{SO2} = Q_f$ x pollutant concentration in fuel x (MW_p/MW_f)

= 5,000 lb/hr x 0.01 x (64/32)

= 100 lb/hr

= 100 lb/hr x 8,760 hr/hr x $\frac{1 \text{ ton}}{2{,}000 \text{ lbs}}$

= 438 tons/year of SO_2

Calculation 5. Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)

Boiler Emissions = Annual Coal Consumption x Emission Factor

TOC = 928,000 tons/year x 0.3 lb/ton = 278,400 lb/year = 139.2 tpy

P_b = 928,000 tons/year x 8.9E-03 lb/ton = 8,259 lb/year = 4.1 tpy

NO_x = 928,000 tons/year x 9 lb/ton = 8,352,000 lb/year = 4,176 tpy

CO = 928,000 tons/year x 0.6 lb/ton = 556,800 lb/year = 278 tpy

Calculation 5. Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)

Estimating Uncontrolled Emissions for SO_2

SO_2 Emissions = Annual Coal Consumption x (Emission Factor x Coal Sulfur Content)

= 928,000 tons/year x (39 lb/ton x 1.87) = 67,679,040 lb/year

= 33,840 tpy

Calculation 5. Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)

Estimating Controlled Emissions

Controlled Emissions = Uncontrolled Emissions x (1 - Efficiency/100)

Total PM = 2,858 tpy x (1-75/100) = 2,858 tpy x (0.25) = 715 tpy

SO2 = 33,840 tpy x (1-93/100) = 33,840 tpy x (0.07) = 2,369 tpy

Calculation 5. Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)

Temporal Allocation

Seasonal emissions = Seasonal throughput fraction x annual emissions

Winter PM = 0.5 x 715 tpy = 357.5 tons

Spring PM = 0.2 x 715 tpy = 143 tons

Summer PM = 0.1 x 715 tpy = 715 tons

Fall PM = 0.2 x 715 tpy = 143 tons

Answers - Area Source Lab

Calculation 1. Estimating County Level Wood Usage (Top-Down Approach)

County Wood Use = State wood use x county households/state households

= 622,000 x 1,242/80,047 = 9,651 cords burned in county of study

Calculation 1. Estimating County Level Wood Usage (Top-Down Approach)

Total waste generated = Total number of households using burn barrels x average waste generated per household

= 997 x 6.75 = 6,730 lb/day

Total Combustible waste generated by households = Total waste generated x percentage of combustible waste

= 6,730 lb/ day x 80/100 = 5,384 lb/day

Total combustible waste = 5,384 lb/day = 2.69 ton/day

Calculation 1. Estimating County Level Wood Usage (Top-Down Approach)

Daily Emissions = Emission Factor

x Total Combustible waste generated (in tons)

CO = 85 lb/ton x 2.69 tons/day = 228.6 lb/day

PM = 16 lb/ton x 2.69 tons/day = 43.03 lb/day

SOx= 1 lb/ton x 2.69 tons/day = 2.69 lb/day

NOx = 6 lb/ton x 2.69 tons/day = 16.14 lb/day

TOC= 21.5 lb/ton x 2.69 tons/day = 57.84 lb/day

TOC = Total organic compound

Calculation 3. State I Gasoline Marketing (Rule Effectiveness/Rule Penetration

Calculating Emissions

$$E = A \times EF \times 1 - (CE \times RE \times RP)$$

$$= 500 \times 11.5 \times 1 - ((0.95)\ (0.8)\ (0.93))$$

$$= 1{,}685 \text{ lb of VOC/day}$$

Calculation 4. Surface Coating Operations (Mass Balances)

Estimating Uncontrolled PM Emissions

Coating density of solid content = Density of coating A - Density of volatile content

= 7.5 lb/gal - 6.2 lb/gal = 1.3 lb solids/gal

Uncontrolled PM emissions = Density of solid content x annual usage x (1-transfer efficiency)

= 1.3 lb/gal x 1,600 gal/yr x (1 - 0.6)

= 832 lb/yr or 0.416 tpy

Calculation 4. Surface Coating Operations (Mass Balances)

Estimating Controlled PM Emissions

Controlled PM Emissions = Uncontrolled PM x (1 - Control efficiency)

= 0.416 x (1 - 99/100) = 0.00416 tpy of solids

Calculation 5. Surface Coating (Per Employee Emission Factor)

Calculating Area Source Emissions

VOC emissions from area sources = area source employment x average coating usage x % VOC x coating density

= 900 employees x 12 gal/yr x 7.5 lb/gal x 45/100

= 36,450 lb/yr

= 18.23 tpy of VOC

Calculation 6. Emissions from Benzene Loading Operations (Emission Factor)

$$L_L = 12.46 \times \frac{S \times P \times M}{T}$$

$$L_L \text{ (lb/103 gal)} = \frac{12.46 \times 0.6 \times 2 \text{ psia} \times 78 \frac{\text{lb}}{\text{lb - Mole}}}{540^{o} \text{ R}}$$

= 2.16 lb benzene/1,000 gal

Toxics Lab

Example Calculation #1

Actual Annual and Potential Acetaldehyde Uncontrolled Emissions from a Natural Gas-Fired Heater

Given: *Actual hours of operation = 2400 hr/yr at 80% of maximum capacity*

Heat content = 1050 MMBtu/MMCF

Heat input rate = 2 MMBtu/hr

Acetaldehyde emission factor for commercial-sized heater (see NTI documentation) = 1.3 E-08 lb acetaldehyde/MM Btu

Example Calculation #1 (Continued)

Actual Acet emissions$(\frac{\text{lb}}{\text{yr}})$ =
(EF)(*heat* input rate)(annual operation)(%firing capacity)

where:

EF = pollutant emission factor in lb/MMBtu and

heat input rate = maximum firing rate in MMBtu/hr.

Example Calculation #1 (Continued)

$$\textit{Actual}\ \text{Emissions} = (1.3\text{x}10-8\ \tfrac{\text{lb}}{\text{MMBtu}})(2\ \tfrac{MMBtu}{hr})(2400\ \tfrac{hr}{yr})(80\%)$$

$$\text{Potential Emissions} = (1.3\text{x}10-8\ \tfrac{\text{lb}}{\text{MMBtu}})(2\ \tfrac{MMBtu}{hr})(2400\ \tfrac{hr}{yr})(100\%)$$

Actual Emissions = 4.99 x 10-5 lb/yr

Potential Emissions = 6.24 x 10-5 lb/yr

Example Calculation #2

Uncontrolled Actual Annual and Potential Xylene Emissions from a Silk Screen Printing Process

Given:

Constituents of ink thinner (100% VOC by weight, 5% xylene by weight)

Usage of ink thinner = 45 lb/yr

Constituents of ink (10% VOC by weight, 2% xylene by weight)

Usage of ink = 204 lb/yr

Estimated maximum hourly usage = 1 lb ink and 0.3 lb thinner

Example Calculation #2 (Continued)

$$\text{Actual xylene emissions}\left(\frac{\text{lb}}{\text{yr}}\right)=\left[\left(\left(45\,\frac{\text{lb}}{\text{yr}}\right)\left(0.05\,\frac{\text{lb xylene}}{\text{lb}}\right)\right)+\left(\left(204\,\frac{\text{lb}}{\text{yr}}\right)\left(0.02\,\frac{\text{lb xylene}}{\text{lb}}\right)\right)\right]$$

$$=6.33\,\frac{\text{lb xylene}}{\text{yr}}$$

$$\text{Potential xylene emissions}\left(\frac{\text{lb}}{\text{yr}}\right)=\left[\left(\left(0.3\,\frac{\text{lb}}{\text{hr}}\right)\left(0.05\,\frac{\text{lb xylene}}{\text{lb}}\right)\right)+\left(\left(1\,\frac{\text{lb}}{\text{hr}}\right)\left(0.02\,\frac{\text{lb xylene}}{\text{lb}}\right)\right)\right]*8760\,\frac{\text{hr}}{\text{yr}}$$

$$=307\,\frac{\text{lb xylene}}{\text{yr}}$$

Example Calculation #3

Cr(VI) Emissions from a Surface Coating Operation

Given: *Coating usage = 500 gal/year*

Cr(VI) concentration = 0.08% Cr(VI), by mass

Density = 8 lb/gal

Coating transfer efficiency = 40%

Air pollution control device = 80%

Example Calculation #3 (Continued)

$$E_x = (Q_{in} - Q_{out}) * C_x$$

Where:
- E_x = Total emissions of pollutant x
- Q_{in} = Quantity of material entering the process
- Q_{out} = Quantity of material leaving the process as waste, recovered, or in product
- C_x = Concentration of pollutant x

Example Calculation #3 (Continued)

Mass of Cr(VI) entering spray booth:

= 500 gal/yr x 8 lb/gal x .0008 lb Cr(VI)/lb coating
= 3.2 lb/yr

Mass of Cr(VI) removed from spray booth:

From transfer to surface

3.2 x 0.4 = 1.28 lbs/yr

Leaving 1.92 lb/yr

From air pollution control device

1.92 x 0.8 = 1.54 lb/yr

Example Calculation #3 (Continued)

Emission rate = 3.2 lb /yr - 1.28 lb/yr - 1.54 lb/yr

= 0.38 lb/yr

or

Emission rate = 3.2 lb/yr x (1-0.4) x (1-0.8)

= 0.38 lb/yr